

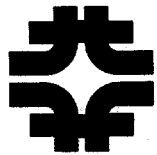
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\bar{p} Note #378

Potential Airborne Problems from Air
Activation in the \bar{p} Target Vault

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During the operation of the \bar{p} target, protons will traverse an air space and result in activation of the air. Prior experience at Neutrino has shown this to be the case. Design of the air flow and ventilation schemes for the \bar{p} target area considered this problem.

Calculation

The rate of production of various isotopes is estimated using the formula:

$$\frac{dR}{dt} = \sum \sigma_i n N_i d$$

σ_i - cross section for production by
 i^{th} target

n - incident flux rate

N_i - i^{th} target density

d - target length

The beam in air is well defined upstream of the \bar{p} target but the downstream scatter and secondaries complicate matters.

As an estimation we use a uniform distribution of the primary beam ($n = 3 \times 10^{12}$ p/2sec) over an area of 1 cm^2 . We are concerned with the target atoms of oxygen and nitrogen for production of ^3H , ^{14}C and ^{13}N each having half lives of 10 minutes, 20 minutes and 12.2 years respectively (a hold up time of 20 minutes is incorporated in the design to allow for decay of

shorter lived isotopes such as ^{15}O and ^{16}N). Oxygen and nitrogen have a fraction by weight in air of 23% and 75.5% and the density of air is $1.2 \times 10^{-3} \frac{\text{gm}}{\text{cm}^3}$. Then our target atom densities are:

$$(1.2 \times 10^{-3} \frac{\text{gm}}{\text{cm}^3}) (0.23) (6.02 \times 10^{23} \frac{\text{atoms}}{\text{Mole}}) \left(\frac{1 \text{ Mole}}{16 \text{ gms}} \right) = 1 \times 10^{19} \frac{\text{oxygen atoms}}{\text{cm}^3}$$

$$(1.2 \times 10^{-3} \frac{\text{gm}}{\text{cm}^3}) (0.755) (6.02 \times 10^{23} \frac{\text{atoms}}{\text{Mole}}) \left(\frac{1 \text{ Mole}}{14 \text{ gms}} \right) = 3.9 \times 10^{19} \frac{\text{nitrogen atoms}}{\text{cm}^3}$$

Using the cross sections from table 7.IV in 'Accelerator Health Physics' ⁽¹⁾ and a target length of 12 feet we get:

$$^{12}\text{C} - \left[(2 \times 10^{-26} \text{ cm}^2) \left(\frac{10^{19} \text{ atoms}}{\text{cm}^3} \right) + (2 \times 10^{-26}) \left(\frac{4 \times 10^{19} \text{ atoms}}{\text{cm}^3} \right) \right] \left(\frac{3 \times 10^{12} \text{ p}}{2 \text{ sec}} \right) (366 \text{ cm}) =$$

$$1.1 \times 10^9 \frac{\text{atoms}}{2 \text{ sec}}$$

$$^{13}\text{N} - \left[(1 \times 10^{-26} \text{ cm}^2) \left(\frac{10^{19} \text{ atoms}}{\text{cm}^3} \right) + (3 \times 10^{-26}) \left(\frac{4 \times 10^{19} \text{ atoms}}{\text{cm}^3} \right) \right] \left(\frac{3 \times 10^{12} \text{ p}}{2 \text{ sec}} \right) (366 \text{ cm}) =$$

$$= 1.4 \times 10^9 \frac{\text{atoms}}{2 \text{ sec}}$$

$$^3\text{H} - \left[(3 \times 10^{-26} \text{ cm}^2) \left(\frac{10^{19} \text{ atoms}}{\text{cm}^3} \right) + (3 \times 10^{-26}) \left(\frac{4 \times 10^{19} \text{ atoms}}{\text{cm}^3} \right) \right] \left(\frac{3 \times 10^{12} \text{ p}}{2 \text{ sec}} \right) (366 \text{ cm}) =$$

$$= 1.6 \times 10^9 \frac{\text{atoms}}{2 \text{ sec}}$$

These correspond to a production of $12 \frac{\mu\text{Ci}}{2 \text{ sec}}$ of ^{12}C , $32 \frac{\mu\text{Ci}}{2 \text{ sec}}$ of ^{13}N

and $58 \frac{\mu\text{Ci}}{2 \text{ sec}}$ of ^3H .

Now accounting for the 20 minute delay time during discharge and dilution by the air flow through the vault target space of $9.3 \times 10^5 \frac{\text{cm}^3}{2\text{sec}}$ (nearly one complete air change @ 1000 cfm) we have discharge concentrations of:

$$\frac{12 \mu\text{Ci}}{\text{pulse}} \left(\frac{1}{9.3 \times 10^5 \frac{\text{cm}^3}{\text{pulse}}} \right)^{(\frac{1}{2})^{(20/20)}} = 6.5 \frac{\mu\text{Ci}}{\text{cm}^3} \quad {}^{12}\text{C}$$

$$\frac{32 \mu\text{Ci}}{\text{pulse}} \left(\frac{1}{9.3 \times 10^5 \frac{\text{cm}^3}{\text{pulse}}} \right)^{(\frac{1}{2})^{(20/10)}} = 8.6 \frac{\mu\text{Ci}}{\text{cm}^3} \quad {}^{13}\text{N}$$

$$\frac{58 \mu\text{Ci}}{\text{pulse}} \left(\frac{1}{9.3 \times 10^5 \frac{\text{cm}^3}{\text{pulse}}} \right)^{(\sim 1)} < .0001 \frac{\mu\text{Ci}}{\text{cm}^3} \quad {}^3\text{H}$$

At the site boundary these concentrations are on the order of 10^5 lower. The Laboratory guide of maximum permissible concentrations are reproduced in Table 1. (2)

Discussion

The \bar{p} target service building is designed with a positive pressure in respect to the target vault and pre-target tunnel enclosure. In addition cable penetrations etcetera are to be sealed. However, if a "short circuit" develops in the ventilation system the concentrations calculated above could result in a submersion dose of .8 mrem/hr. (over 1600mrem/year at 40 hours per week). Hence, it will be necessary to monitor the \bar{p} target service building with an installed constant air monitor to forewarn us of such problems. A hard line sample point

should be included so that the tunnel may be measured prior to access to confirm levels in the tunnel. The exhaust at F18 should be monitored in a manner similar to the Neutrino area for the site environmental records.

The discussion to this point has been for gaseous airborne activity but the possibility of particulate activity such as from damage to the target must be considered. Protection is provided through the use of an absolute (HEPA) filter in the exhaust path from the target vault into the tunnel. This filter will remove particles in size down to a few micron with 99% efficiency. There are also two 90° bends in the air flow path from the vault. If the target vaporized, molecules and particles will freeze to the shield walls within the vault before getting to the HEPA filter. Some periodic maintenance will be required and there are standard containment provisions with this unit for exchange of filters without spread of contamination.

In addition to the filters, the delay time in the exhaust cycle prevents immediate discharge to the atmosphere and allows time for operator action as a backup measure (e.g. turn off ventilation).

Conclusion

Airborne radioactivity will be a concern for operation of the anti-proton target area. Design considerations have been implemented to reduce the routine release of gaseous radioactivity and prevent particulate releases. Routine monitoring will be required.

References

1. H. Patterson and R. Thomas, Accelerator Health Physics
Academic Press (1973).
2. Radiation Guide fourth edition April 1983.

TABLE 1

Calculated Concentration Guides (Air) for radiation workers and for the general population. Units are $\mu\text{Ci}/\text{m}^3 = \text{pCi}/\text{cm}^3$. The routes of exposure are SOL = soluble, internal exposure to one or more organs; INSOL = insoluble, exposure to lung; SUB = external exposure from submersion in a cloud of radioactive gas.

	<u>Route of Exposure</u>	<u>Radiation Worker 5 rem/year 40 hours/week</u>	<u>General Population 0.17 rem/year 168 hours/week</u>
^3H	SOL	5. ^a	0.06 ^a
^7Be	INSOL	1. ^a	0.013 ^a
^{11}C	SUB	59. ^b	0.02 ^b
^{13}N	SUB	41. ^b	0.017 ^b
^{15}O	SUB	27. ^b	0.015 ^b
^{41}Ar	SUB	47. ^b	0.013 ^a

NOTES TO TABLE:

- a. DOE Manual, Chapter 0524.
- b. M. Hofert, "Radiation Hazard for Induced Activity in Air..."; Proc. Second Int'l Conf. on Accel. Dosimetry and Experience, 1969. The values for radiation workers taken from this work are based on β -exposure to the skin resulting from submersion in a cloud of 4 meters radius. MPC's for the general population are based on γ exposure from a hemispherical cloud of infinite radius.

REFERENCES

1. A. Peetermans, CERN Report 72-12 (1972), Geneva, Switzerland.
2. P. J. Gollon, "A Summary of MPC's for Accelerator-Produced Activity in Air". Fermilab Radiation Physics Note #20 1978.
3. K. Goebel (Ed.), CERN Report 71-21, p. 3, Geneva, Switzerland. The MPC values selected by Goebel are similar to those selected and discussed in ref. 2.